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(71) Applicant *(for all designated States except US)*: BRITOIL PLC [GB/GB]; Centenary House, 100 Morrison Street, Glasgow G5 8LP (GB).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)* : DOYLE, Peter, John [GB/GB]; Oakdene Cottage, Hampden Road, Speen, Aylesbury HP17 ORU (GB). PIPE, Anthony, Frank [GB/GB]; 33 Sandalwood Avenue, Chertsey, Surrey KT16 9PD (GB).

(74) Agent: LAWSON, David, Glynne; Marks & Clerk, 57/60 Lincoln's Inn Fields, London W.C. 2A 3LS (GB).

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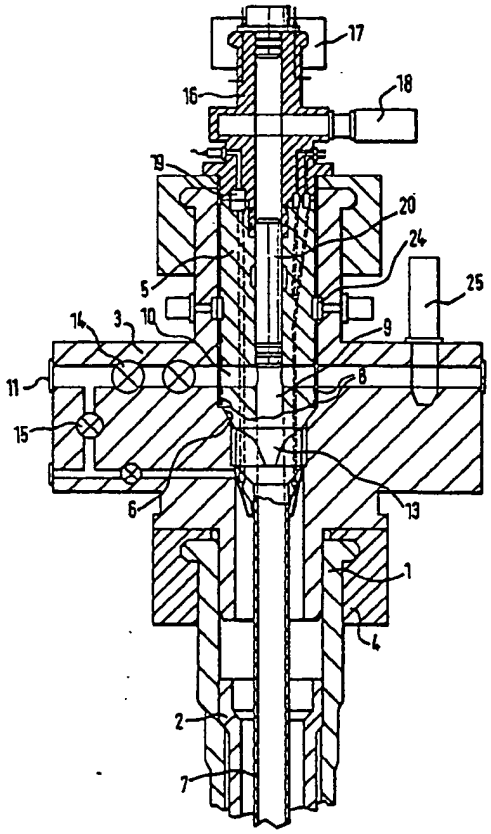
(54) Title: UNDERWATER WELL EQUIPMENT

(57) Abstract

An underwater well head (1) is provided with a tree body (3) in which a tubing hanger (5) is directly seated and housed. The tubing hanger has lateral supports (10) aligned with ports (11) in the tree body, and control valves (14, 15) are mounted directly in the tree body. The tubing hanger also has a vertical through passage (9) of the same diameter as the tubing (7), for providing in-line access, normally closed by a crown plug (20). In normal operation, produced or injected fluid passes through the ports (11), sealing being provided by upper and lower peripheral seals (8) on the tubing hanger. Above the tubing hanger is primary tree cap (16) with electrical and hydraulic connectors interfacing with the tubing hanger. On the primary cap (16) is a workover cap (17) providing for wire line access.



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"UNDERWATER WELL EQUIPMENT"

This invention relates to underwater well head equipment, and in particular to a novel tree.

In conventional well heads, the tubing hanger is seated in the well head body, onto which the tree is mounted. This arrangement has numerous practical disadvantages: the size of the valves in the tree is determined by the size of the tubing and tubing hanger, and access to electrical and hydraulic connectors for downhole equipment is difficult.

There is a requirement for a well head and tree system which will allow through-tree tubing operation.

A tree system produced by National Supply consists of a production upper body, a well head connector, and a main tree body. The upper body carries the well head connector, tubing hanger landing profile, and tubing hanger lockdown system. It is ported for downhole safety valve control line, and a side-entry annulus connection. It allows unrestricted passage for downhole tubing and associated equipment. Tree valves are situated above the tubing hanger.

This system has a number of disadvantages. The valve actuators are large; sealing surfaces in the tree are liable to damage during installation of the tubing; the system does not lend itself readily to vertical annulus access or dual-string arrangements; the provision of extra downhole facilities is not readily provided for; there is only limited space at the interface between the tubing hanger and tree, which hampers the provision of downhole equipment connectors such as electrical instrumentation contacts; there is a risk of contamination of downhole safety valve control lines; high point loadings can arise at the tree/tubing hanger interface.

The Hydril completion diverter has a diverter valve above the tubing hanger, which can be set to divert flow laterally through master valves, or alternatively can permit straight-through vertical access. The diverter valve contains an insert which can be removed to provide large-diameter vertical access so that the tubing hanger, tubing and packer can be run through the valve. With this system, conventional-sized valves and actuators can be used and valves can be integrated with the tree body. However, the relatively complex diverter valve arrangement requires special sealing at the tubing hanger and ball valve interface, and sealing faces and seals may be prone to damage during

installation or workover operations if the valve ball is not correctly aligned. Owing to limited space and the movement of the valve ball, the provision of hydraulic and electrical connections for downhole equipment at the interface between the tree and tubing hanger is not easy.

An object of the present invention is to provide an arrangement in which through vertical access of full diameter is provided, and electrical and hydraulic connections for downhole equipment can be provided relatively easily, in a simple and reliable structure.

According to the present invention, the tubing hanger is seated in the tree body. Access to the tubing is laterally, through passages provided in the tubing hanger and tree body. The tubing hanger can also provide in-line vertical access to the tubing. Preferably, the upper end of the tubing hanger is at or near an upper surface of the tree body, providing a readily accessible interface for connections of various kinds.

The present invention is illustrated by the accompanying drawings in which :

Figure 1 is a vertical section through a well head and tree assembly embodying the invention, and

Figure 2 shows, on a larger scale, a possible multi-string tubing hanger.

Figure 1 shows a conventional well head 1 and a conventional casing 2. A tree body 3 embodying the invention is mounted on the well head by a connector 4.

A tubing hanger 5 is seated on a load bearing shoulder 6 in the tree body, so that the tubing hanger is housed in the upper part of the tree body.

The tubing hanger has a cross-ported manifolded top section which forms part of the tubing hanger body, which in turn is an integral part of the downhole tubing 7. It is provided with main seals 8 to seal it in the cylindrical seat in which it is located in the tree body.

The tubing hanger has an axial through passage 9 of the same diameter as the tubing. In the lower part of the tubing hanger, between upper and lower main seals 8, the passage 9 communicates with lateral ports 10 which in turn communicate with outlet ports 11 in the tree body. The bore 9 is normally closed above the ports 10, by a crown plug 12. During normal operation, produced

or injected fluid is diverted through 90°, through the outlet ports 11 in the tree body. The seals 8 required to isolate the ports are installed with the tubing hanger assembly.

The tubing hanger and tree body are provided with a hanger orientation cam and slot arrangement 13. For a single string installation, a non-orienting system may be used to instal the tubing assembly into the tree body. For multi-string use, an orientation mechanism is of course essential.

The tree body provides the load bearing seat 6, the lock down system 24 and mating sealing faces for the tubing hanger, and is provided with the fluid ports and production wing and crossover valves as necessary. Figure 1 shows master valves 14 and an annulus crossover valve 15 providing communication with the well annulus, and vertical or horizontal actuators 25. The tree body may be configured to permit vertical mounting of valves, actuator and flowline connections, thereby simplifying subsea installation and removal of such components.

The lower half of the tree body is configured to mate with the well head, while the top of the tree body interfaces with the primary tree cap 16 or, during

workover, with the BOP and main riser system.

Mounting the valves in the tree body provides protection from external damage. There is no need for the conventional separate tree insert, and it is not necessary to use large valves or actuators, regardless of the casing size or the outside diameter of the tubing hanger. For example, conventional three inch valves can be used.

The tree cap, unlike conventional arrangements, is split into two sections. The main or primary section 16, interfaces with the tree body 3 and provides secondary load and pressure containment of the tubing hanger. When tubing removal is necessary the primary cap is removed and replaced with the BOP and riser assembly. The secondary tree cap 17, which is mounted onto and forms part of the primary tree cap, provides a smaller access and mounting location for a small wireline BOP system thus simplifying requirements for general wireline workover and re-entry. A swab valve 18 mounted in the primary cap section ensures additional safety during the wireline operation and secondary tree cap removal. This is backed up by the wireline removable crown plug 12 in the top entry part of the tubing hanger manifold body.

The upper end face of the tubing hanger is very close to the top of the tree body, where it forms an interface with the primary tree cap 16. At this interface, electrical connectors 19 and hydraulic connectors 20 are provided. This provides an improved environment for instrument and downhole pump electrical connectors, and better access to such connectors, to permit diver, ROV or self-aligning coupler make-up after the tree body has been installed.

An analogous construction can be used for a multi-string installation. By way of example only, Figure 2 shows a tubing hanger 5a with primary and secondary seals 8and adjoining parts of the tree body 3a and primary tree cap 16a, for an installation comprising two production strings 21 as well as electrical instrument cables and lines 22, and hydraulic lines 23 to a downhole pump.

The configuration proposed is ideal for single satellite and twin cluster well applications. It can also be modified for use with TFL systems and top entry fluid connection systems such as may be required on a template/manifold application.

As the tree permits a high level of functions at the tubing hanger interface the benefit of multizone

production, artificial lift and improved instrumentation accommodation could be employed for platform based wells.

The proposed tree fulfils two functions necessary for economical and efficient subsea oil production. These functions are :

- The ability to remove the downhole tubing system and its components without disturbing the tree and its associated interfaces.

- The ability to accommodate tubing assemblies for multizone production and TFL servicing plus downhole equipment such as gas lift valves, artificial lift pumps and electronic instrumentation.

Obviously the more complex the downhole system becomes the more likely it is that servicing will be necessary. The ability to remove and service the equipment quickly and easily is therefore essential. The configuration proposed covers these aspects.

A summary of the features of the proposed design is as follows :

- Permits safe withdrawal of tubing and hanger without

removing the tree, thus allowing complex downhole equipment requiring regular maintenance to be used.

- Permits any size of tree valve to be used regardless of the tubing and casing size.

- As the tree valves do not govern the size of the tubing hanger its size may be increased to accommodate any number of downhole tubing strings. Similarly the areas required to mount electrical and hydraulic connectors for downhole equipment, can be provided.

- Provides good access to the mounting interface with electrical, instrumentation hydraulic and downhole service connections.

- Permits use of standard BOP and riser assemblies.

- Permits orientation of tubing.

- Offers a low tree profile.

- Permits vertical positioning of valves and connectors to assist in subsea intervention, installation or removal.

- Allows safe disconnection of the tree cap.

- Can be configured for use as single satellite tree or as an integral installation on a template/manifold system.

- Can be adapted for platform use.

Vertical access to the annulus is also obviously possible.

- As the tree cap is divided into two sections the use of a smaller wireline BOP is possible thus eliminating heavy equipment requirements for routine surface vessel intervention.

CLAIMS:

1. A well head comprising a tree body, a well tubing hanger seated in the tree body, and at least one lateral passage provided in the tree body and in the tubing hanger providing access to the tubing.

2. A well head according to claim 1 in which the tubing hanger provides direct in-line vertical access to the tubing.

3. A well head as claimed in claim 1 or 2 in which the upper end of the tubing hanger is at or adjacent an upper surface of the tree body.

4. A well head as claimed in claim 1, 2 or 3 in which the tubing hanger is provided with peripheral seals above and below the lateral access passage or passages.

5. A well head as claimed in any preceding claim, in which flow control valves for produced or injected fluid are provided within the tree body.

6. A well head as claimed in any preceding claim having a tree cap, which cap comprises two portions of which a primary portion interfaces with the tree body and provides containment for the tubing hanger, and a secondary portion mounted on the primary portion and adapted to provide for wireline access.

7. A well head as claimed in claim 6 having electrical and/or hydraulic connecting means at an interface between the primary portion of the cap and the upper end face of the tubing hanger.

8. A well head, substantialy as herein described with reference to Figure 1 or Figure 2 of the accompanying drawings.

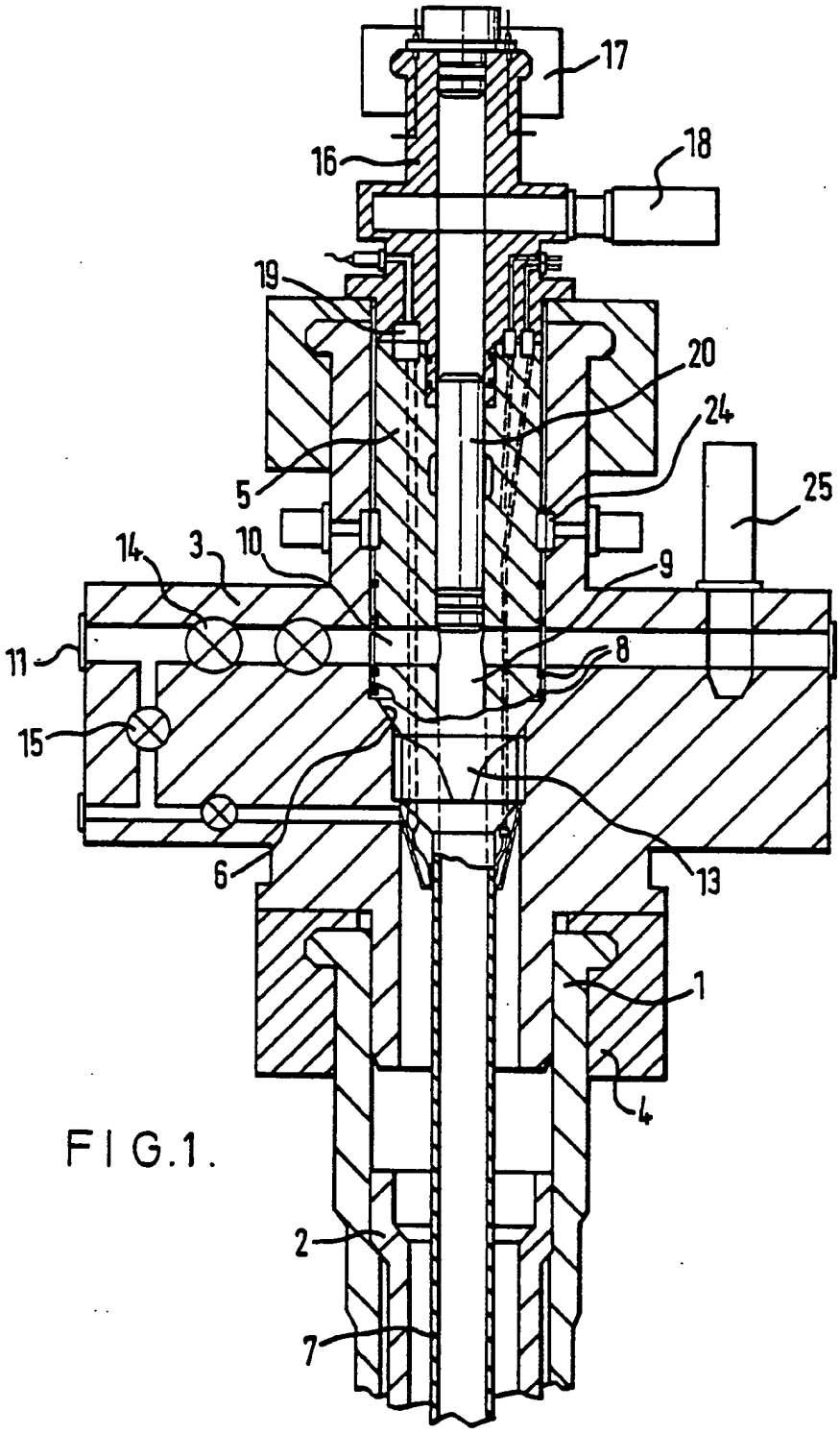

FIG.1.

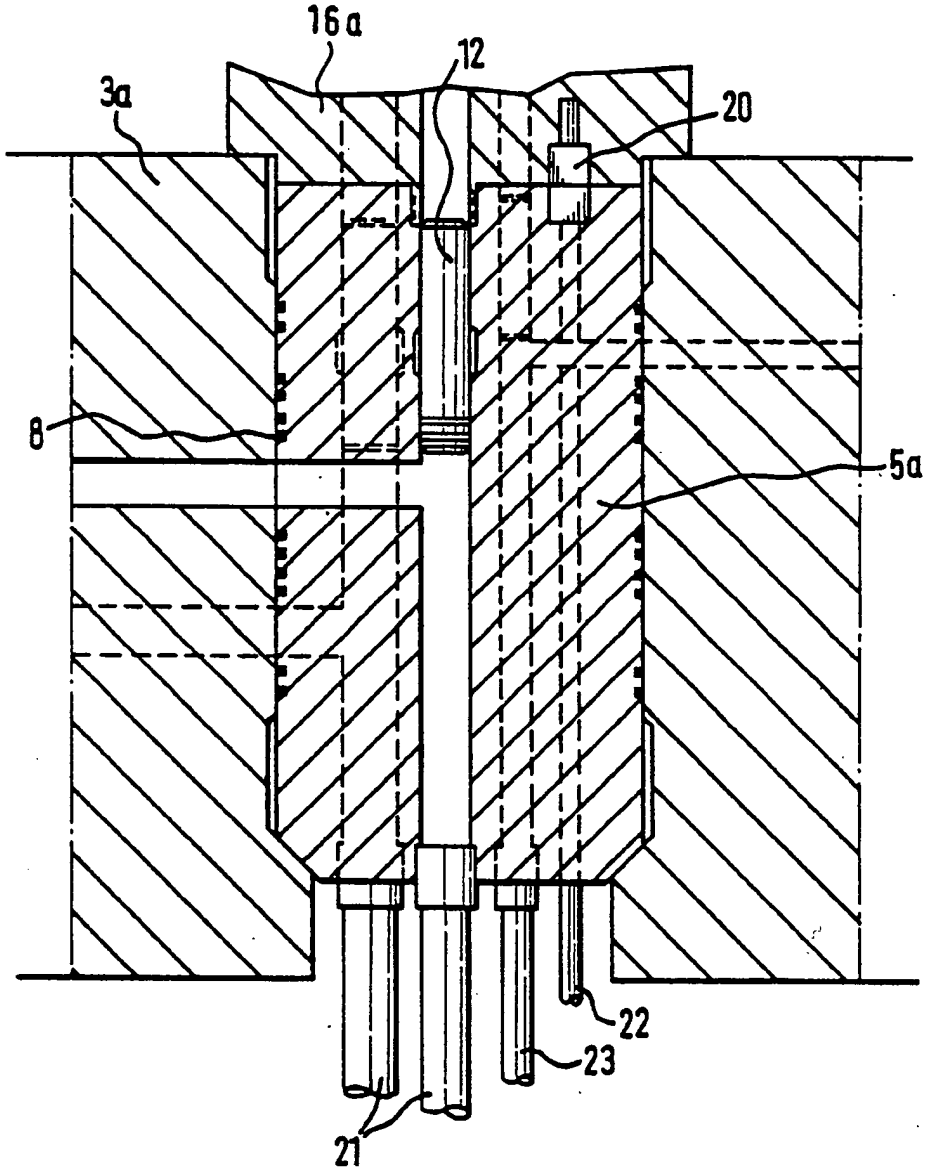

FIG.2.

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 85/00422

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC[4]: E 21 B 33/035; E 21 B 33/047

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC[4]	E 21 B

Documentation Searched other than Minimum Documentation to the Extent that such Documents are included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [10]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	US, A, 2889886 (GOULD) 9 June 1959, see column 2, lines 38-44; column 4, lines 15-29; column 5, line 14 - column 6, line 2; column 7, line 55 - column 8, line 5; column 10, lines 9-43	1-5
A	--	6,7
A	US, A, 3451481 (LANMON) 24 June 1969, see column 3, line 13 - column 4, line 25	1-6
A	--	
A	US, A, 3454084 (SIZER) 8 July 1969, see figure 2	6
A	--	
A	US, A, 3638732 (HUNTSINGER) 1 February 1972, see abstract; figure 6	7

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
29th November 1985	18 DEC. 1985
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	G.L.M. Kruydenberg

Form PCT/ISA/210 (second sheet) (January 1985)

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON

INTERNATIONAL APPLICATION NO. PCT/GB 85/00422 (SA 10936)

This Annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 09/12/85

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Patent document cited in search report	Publication date	Patent family member(s)		Publication date
US-A- 2889886		None		
US-A- 3451481	24/06/69	None		
US-A- 3454084	08/07/69	None		
US-A- 3638732	01/02/72	FR-A-	2076036	15/10/71
		GB-A-	1313553	11/04/73